FASTENERS

VITAL IN EVERY INDUSTRY

PUBLISHED BY AMERICAN INSTITUTE OF BOLT, NUT, AND RIVET MANUFACTURERS

VOLUME ONE • NUMBER THREE

A Triumph of Fasteners

FROM the earliest log rafts, laced together with vines and strips of bark, to the sleek, modern queen of the seas, the development of ships and ship construction is a saga of fasteners.

Man's ingenuity led him to canoes of skin or bark bound down with cords, and then to wooden ships fastened together with pegs and treenails. The employment of metal bolts next made possible the construction of larger, more seaworthy craft, and then came the ships of steel construction, in ever growing size.

The largest ships of today are truly triumphs of fasteners. Literally millions of rivets, bolts and nuts enter into the construction of each of these achievements in naval architecture, binding the various components into seaworthy structures capable of combating the combinations of elements encountered in maritime service.

AMERICAN INSTITUTE OF BOLT, NUT AND RIVET MANUFACTURERS

1550 HANNA BUILDING

HERMAN H. LIND
PRESIDENT
JAMES D. EGGERS
SECRETARY-TREASURER
WM. C. STEWART
TECHNICAL ADVISER

CLEVELAND 15, OHIO

In the Interests of Better Standards–

The Fasteners Industry, comprising the manufacturers of bolts, nuts, screws, and rivets, is an old industry. As a service industry to other industries, it has developed the various types of products needed. It has cooperated with other bodies in establishing standardized dimensions so that the products are interchangeable. Dimensional standards are reproduced in the Institute's handbook "Bolt, Nut and Rivet Standards". However, there has been little standardization of physical properties, test methods, and similar requirements. In the absence of standard specifications, many users have promulgated their own, and frequently there are different specification requirements for bolts which are intended for similar uses.

Recently the Committee on Standards and Technical Practices of the Institute has been instructed to explore the need of coordinating existing similar specifications. As a first step, it is desired to compile a file of existing user specifications for study purposes with the idea of comparing them. Will you as a user who has specifications please forward them to this office? Possibly as a result of war activity and recent developments you feel that new requirements should be developed, so we will welcome any further information and suggestions.

Herman H. Lind
President

P. S. The return post card....

is enclosed for two reasons: so that we may have your correct postal zone number (required by many post offices); also, to make sure that every interested person receives future issues of "Fasteners." The 25,000 copies published just about cover the present mailing list and new requests are coming in daily. So, won't you please fill in and return the card? Thank you.

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Heads and Threads afloat

by KENT THORNTON, acting naval architect

THE AMERICAN SHIP BUILDING COMPANY
CLEVELAND, OHIO

Keel laying scene at Cleveland Yard.

A SHIP is easily the most complicated large structure built by man. It is a hotel and warehouse, equipped to create its own power and light, its own fresh water supply and it must be otherwise self sufficient for long voyages. Warships carry guns, armor, fire control apparatus and detection devices. This entire combination is assembled as compactly as possible in a hull that floats and which must be controlled in conflict with high winds and high seas.

Every type of fastener is used by more than a dozen

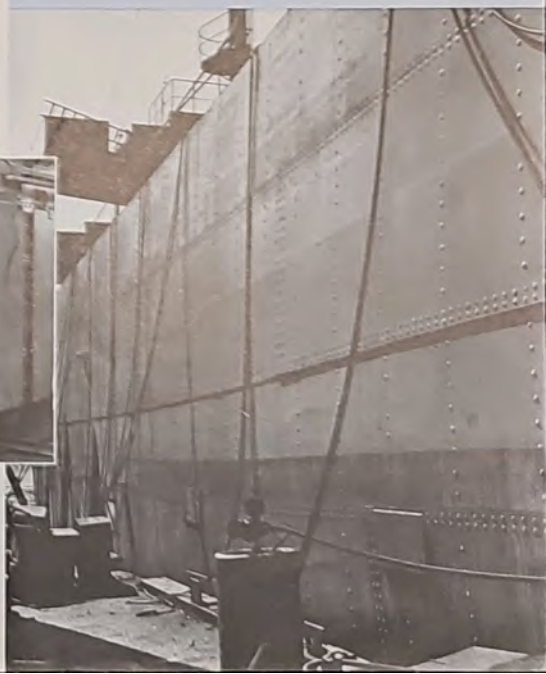
crafts in ship building. The marine architect has many factors to consider beyond those involved in ordinary construction. The action of fresh or salt water, the strains and stresses of rugged use, and the necessity for quick, easy replacement of vital parts are prime considerations.

Merchant ships carried a record breaking 62,000,000 tons of cargo from all United States ports in 1943. On the Great Lakes 86,000,000 long tons of iron ore were moved in a short shipping season in the most efficient bulk cargo fleet in the world. Some of the vessels in service at present, with riveted wrought iron hulls, are almost 60 years old. There are scores of lake vessels over 30 years of age in regular service. War ships built on the Great Lakes range from small landing craft to frigates and submarines over 300 feet in length.

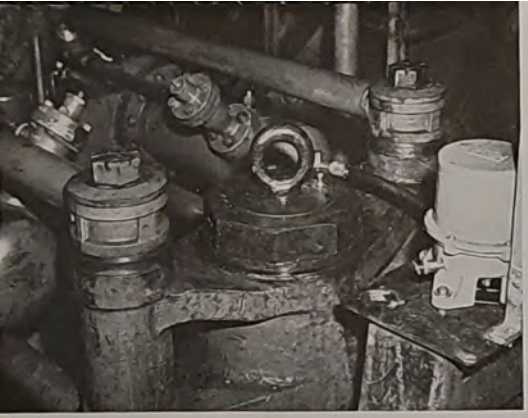
"Bolting up" a keel section. Thousands of temporary or service bolts are used to hold the assembly in position prior to riveting. The temporary angle clips along the sides will be removed after riveting.

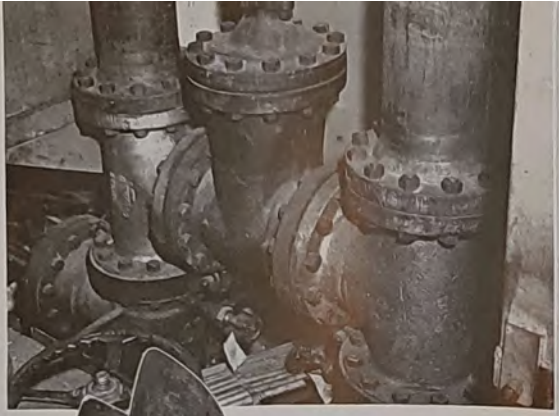
The completed riveted shell, as it appears after caulking and prior to the final painting. All shell rivets are countersunk on the outside to permit caulking the heads. The point of the rivet is on the inside and is a button point.

Completing a "bolting up" operation on a galvanized shell plate. When plates are properly regulated, alternate service bolts are removed, the holes reamed and countersunk and rivets applied. After this first riveting operation, the process is repeated.



Bolts are in some cases used in the final construction in order to make certain assemblies removable. Here are three watertight doors, the frames of which may require removal during the life of the ship.





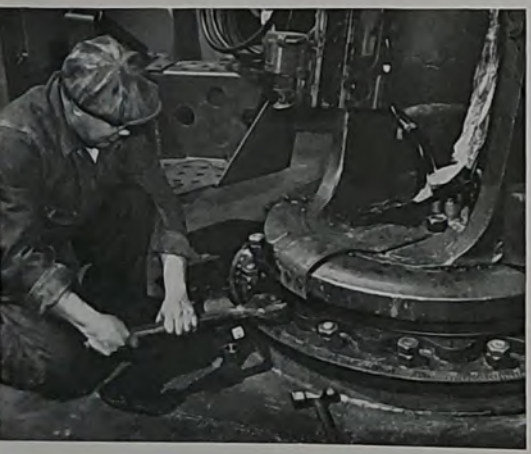
Above: Thousands of types of bolts, nuts and studs of various materials, are used in machinery installations aboard ship. The large nut in the foreground, which is threaded on the upper end of the rudder stock, carries the entire weight of the rudder assembly.

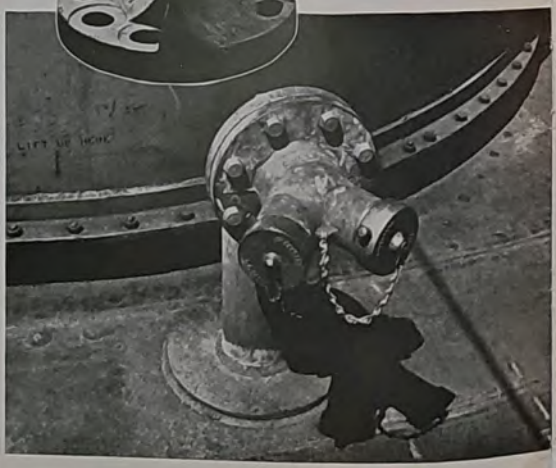
Above-Right: Piping and pipe fittings throughout a combat vessel are fitted up with bolted flanges.

Below: All ordnance equipment is applied to the ship with alloy steel stud bolts which are carefully fitted into reamed holes in order that the intense reaction from firing will not produce undue stress in any single stud.

Below-Right: In order that the smoke stacks may be assembled in the shops and erected on the ship, a bolted flanged connection is provided between stack and deck.

Right: Commercial vessels usually have propellers with detachable blades, permitting ready replacement of individual blades in case of damage.





SCREW THREAD STANDARDIZATION and the *War Effort*

by COLONEL H. B. HAMBLETON

Chief, Inspection & Engineering Administrative Sections, Production Service Branch, Office, Chief of Ordnance, U. S. Army

. . . standardization and interchangeability have enabled the Ordnance Department to satisfy tremendous requirements for threaded products with minimum confusion . . . Ordnance standards conform insofar as practicable to established American standards. . . .

ONE OF THE basic principles of modern production is the use of the screw thread. The screw is so common that the average person accepts it without question or thought of its derivation. The fitting of the first screw thread was a laborious task requiring many man hours with little or no chance of interchangeability. The screw thread was developed through years of research, and as conditions arose new types of threads were developed to meet specific conditions. Logically, the next step was their standardization. The realization of the need of such action in the United States resulted in the appointment, by the Franklin Institute on April 21, 1861, of a special committee for the investigation of a proper system of screw threads, bolt heads, and nuts, which could be approved by the Institute and recommended for adoption and general use by American engineers. This committee submitted its report under date of December 15, 1864.

In its report this committee recommended a thread system designed by William Sellers. This thread system specified a single series of pitches for certain diameters from $\frac{1}{4}$ in. to 6 in., inclusive. The threads had an included angle of 60 degrees and a flat at the crest and root equal to $\frac{1}{8}$ of the pitch. This system came into general use and was known as the Franklin Institute thread, the Sellers thread, and commonly as the United States Standard thread.

The accomplishments realized in the adoption of the Franklin Institute or United States Standard thread in 1864 fulfilled in a large degree the great need for standard threads by American railroads for the development of their lines and equipment. In May, 1868, this thread was adopted by the United States Navy. In recent years numerous organizations have carried forward the standardization of screw threads. The American Society of Mechanical Engineers, the Society of Automotive Engineers, the National Bureau of Standards, and promi-

Gages used for checking the eleven internal and eleven external threads in a round of ammunition.

nent manufacturers of threaded products have been the chief influences in standardization of screw threads in this country.

While the United States Standard thread system fulfilled the need in the period of the development of our great railway systems, it did not fully meet the requirements of modern manufacture because of the need for additional standard sizes and pitches developed in other industries, and especially because of the need for definitely specified size tolerances of threaded parts. To fulfill the first of these needs a thread system having finer pitches than the United States Standard system was recommended by the Society of Automotive Engineers, and a machine-screw thread series which provided smaller sizes of screws than the United States Standard threads was recommended by the American Society of Mechanical Engineers. The progress of machine design and manufacture has established an extensive use of these fine thread series.

The difficulties encountered in obtaining enormous quantities of war materiel during World War I pointed out to government establishments, as well as to private manufacturers, the need for definite and complete specifications for materiel required. To carry out this standardization, through the efforts of several engineering societies, the National Bureau of Standards and manufacturers of screw thread products, a petition was presented to Congress requesting the appointment of a commission to investigate and promulgate standards for screw threads. The National Screw Thread Commission was authorized by an Act of Congress approved July 18, 1918. In 1933, the National Screw Thread Commission was superseded by the Interdepartmental Screw Thread Committee. This committee consists of representatives of various government departments with liaison representatives of the American Standards Association appointed from members of various engineering societies. This committee is responsible for the publication of "Screw-Thread Standards for Federal Services" (known as National Bureau of Standards Handbook H25, later revised as H28). Visualizing the problem which the Ordnance Department would be confronted with in time of emergency, screw thread standard gage drawings were prepared covering gages for national coarse and national fine threads, for all sizes up to 1½ in.

diameter for class 1, 2, and 3 fits. Later, gage drawings for 8, 12, and 16 uniform pitch series, class 4 fits, fine and extra fine threads, were added to the list of standards.

Approximately 500 standard gage drawings were prepared and checked to exclude all ambiguous and unnecessary information. This work was completed in peace time when competent designers in both gage and screw thread technique were available and were not burdened with other war time work. A definite system for determining dimensions of special thread gages was also set up consisting of tables, standard forms, and detailed procedures for design purposes.

It was then only necessary for the designer in any establishment to select from the tables the dimensions to be used on the gage drawing. This procedure insured uniformity between the several design agencies of the Ordnance Department. With these very definite procedures established well before this war, the Ordnance Department was able to place its tremendous screw thread requirements with a minimum of difficulties and with the assurance that the customer and the producer would have a definite basis of acceptance. It is believed that this common understanding has been the primary reason why few controversies over threaded products have arisen.

Due to the immense volume and variety of identification resulting from hundreds of contractors, the Ordnance Department initiated the Parts Numbers and Interchangeability Program. One broad purpose of this program is to determine interchangeability of the same items which have existed under a variety of numbers. These items are then consolidated under one official Ordnance number to which their previous numbers are referred.

The standards phase of this program is based upon past Ordnance practice of conforming insofar as practicable, to established American Standards. However, standards requirements peculiar to the Ordnance Department and not common to industry, must also be recognized and provided for. The numbers bracket extending from 100,000 to 500,000 for standards has constituted the numerical basis for the system in use by General Motors, Chrysler, and lately, by International Harvester. As these standards have also been used by a large number of smaller manufacturers, they constitute the nearest approach to a national common denominator for identifying this type of item, as they are in effect automotive industries standards.

It was logical therefore, for the Ordnance Department to adopt these numbers as official for appropriate classes of items. At present, the General Motors Corporation acts as the service agency for the Ordnance Department in assigning these numbers. The numbers within this system which were not adopted by Ordnance were those assigned to the product of some one manufacturer, where this product was functionally and dimensionally interchangeable with that of some competitor.

The number block extending from 500,000 to 1,000,000 is being used for numbering Ordnance standard parts which are not common with automotive industries standards. These numbers are also used to replace automotive industries numbers which were not adopted by Ordnance. The numbers in this series are assigned by the Ordnance Department.

The "taxi" numbering system for Ordnance standard parts has been replaced by the official six-digit system. However, the "taxi" classification number, which usually consisted of the first five characters of the "taxi" part number, is retained as the group classification or drawing number.

Under the above numbering system the Ordnance Department retains control of the standards peculiar to its use and simplifies the problems of industry in identification and specification for items which are, through common acceptance and usage, national property.

200,000,000 *pieces a day!*

by **SAMUEL N. COMLY,** vice president and treasurer
RUSSELL, BURDSALL, AND WARD BOLT AND NUT CO.

SOME YEARS ago, at a dinner, I sat next to a charming young Belgian who was visiting this country for the first time. After a while she asked what business I was in. Not thinking that her classroom English would go far beyond ordinary conversational words, I said I didn't believe she would understand the names of the articles we manufactured. Anyway, I mentioned "bolts and nuts" with the usual half apologetic smile. She came right back with "Oh! I understand. You mean like 'nuts to you?' "

One doesn't have to be a Belgian to laugh at this line of business. The war has raised the public's opinion of our products somewhat, for everybody in the country knows that no plane, ship, tank, gun or any other piece of war equipment can operate until the last single fastener has been put into place. That's elementary. Nevertheless I've talked to many people, in and out of Washington, who think that the problem of an adequate supply of bolts and nuts is nothing to worry about—that there are always plenty on the shelves of hardware stores. Others figure there can't be much of a problem, since no major war production program has been held up for lack of fasteners. Even more significant, I'm afraid that the great majority of people in this country think of the bolt, nut, rivet and screw business as the simplest kind of manufacturing; they think of a bolt factory as perhaps a slightly glorified form of blacksmith shop where a machine makes the same rough scaly product that used to be forged on an anvil.

What could be further from the truth! When you consider the large investment in complicated machinery, heavy enough to cold work carbon steels and alloys and yet accurate enough to achieve precision tolerances, and with a considerable share of the processes and machinery developed by the industry itself—when you consider the multiplicity of types and sizes of machines for all the various operations on a line of products ranging in size from several thousandths of a pound up to over 25 pounds each—when you consider the engineering and tool work involved in designing the exactly correct bulbing and heading punches for the proper flow of the specified analysis of material into the specified size and shape of head—when you consider the intricate problems of metallurgy, chemical and physical properties, and the constantly advancing science of heat treating—when you consider the routing and scheduling problems of an individual factory that each day enters hundreds of orders for thousands of items, each item involving several operations, and each operation using various

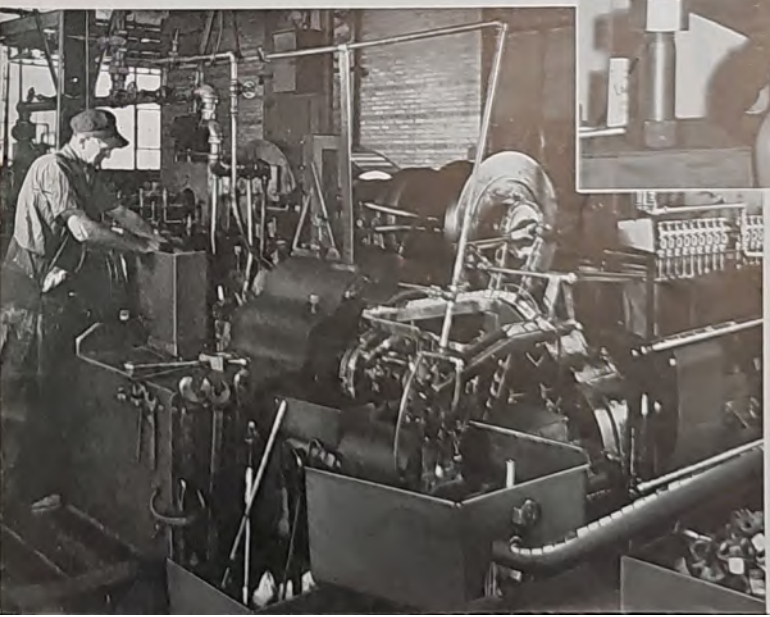
numbers of specially designed taps, punches, dies or other kinds of tools—when you consider that each bolt and nut we ship to our Allies must have a different thread, different dimensions, and different tolerances—I could go on all day, but the point is this—if any person thinks the fastener business is a simple one, he should take a trip through one of our plants, and I am confident he would register a profound respect for the industry that makes the little things which make the assembly of big things possible.

As to size, the public's opinion is correct in that the industry is relatively small, at least as compared to the great corporations whose names everybody knows. None the less, it's hardly correct to classify in the blacksmith category, an industry which uses about 2½ per cent of all the steel rolled by all the steel mills in the country!

Size in itself is not important to the industry. The important thing is that manufacturers have been able to expand their production sufficiently to take care of the war needs of those great corporations and all other producers of the articles that are familiar to everyone—needs totaling over 200 million bolts, nuts, rivets and screws *per day*. The production achievement is even more impressive when it is realized that war materiel, as compared to civilian goods, requires a much greater proportion of special fasteners, whether of different alloys, different shapes, closer tolerances, or more highly finished.

That "a chain is no stronger than its weakest link" is accepted by the public as incontrovertible. Let everybody realize likewise that an end product is no stronger than the fasteners with which it is put together.

Beauty and the bolt.



Automatic machinery of almost unbelievable precision has made it possible for the fasteners industry to take care of the tremendous war needs.

What about magnetic particle inspection?

A *Challenge* to the Fasteners Industry

by W. E. THOMAS, second vice president

Magnaflux Corporation

THE STATEMENT that "magnetic particle inspection is rejecting too many of our products" is sometimes expressed by management, production, engineering, and inspection personnel. The purpose of this brief article is to point out the fallacy of that statement, and to present a program which should challenge the maker and user of fasteners—specifically of bolts. Certain facts which should be self-evident but which are not understood by all are:

1.—What is the purpose of any inspection program? Harry B. Pulsifer in his book "Inspection of Metals" expresses it succinctly as follows: "The inspector's job is not so much to reject stock that can be criticized as to pass forward as much as can be used successfully."

2.—No material is perfect—all have certain inaccuracies, blemishes, or defects.

3.—Instruments, gauges and devices for the testing of things are never perfect in themselves and always require a degree of knowledge and experience for their proper use.

4.—Whatever the inspection method used to check for whatever purpose—a tolerance must be decided on, a tolerance understood and agreed to by the material producer, the part fabricator, the final product manufacturer and the ultimate user.

Applying these facts to the subject of bolts, and to the inspection of them by means of the magnetic particle testing machine, the plain facts are these:

1.—Due to the necessary introduction of large numbers of contractors and inspectors unused to aircraft production and engineering requirements, there has been a cry for perfection. This is as unnecessary and impossible as it is in the fields of automotive, machine tool, railroad, or other fields of manufacture. Granted that strength-weight ratios are higher; granted that failure of primary structure may cause loss of life or property, still it is necessary and satisfactory to pass through, inspection parts which are not perfect but which are satisfactory for the purpose intended.

2.—It is impossible to think of perfection when considering a bolt. It may be made from bar or wire, varying somewhat in analysis; it may contain some inclusions or seams; its surface may contain some blemishes; it may not be straight; there may be small laps formed in heading; it may be somewhat off in diameter, or length, or radius of fillet. In other words, it is seldom equal to a perfect specification for material, size, finish, plating, etc.

3.—A magnetic inspection machine is capable of wide variations in sensitivity. It can be used in such

a manner, for example, as to give indications of the flow lines in a forging, or to produce indications of sharp changes of section in a part, neither of which are, obviously, in any manner considered as defects. The operator of such a machine can, therefore, if not properly trained or without sufficient experience and knowledge, obtain indications on almost any steel part and, erroneously calling them defects, reject the part to the scrap pile when that part may have been perfectly suitable for the purpose intended.

4.—The standards of acceptance and rejection by magnetic particle inspection must be fixed and agreed upon—the allowable tolerance must be known.

What do we find in specifications and on blue prints as to magnetic particle inspection? Frequently we see phrases such as "Magnaflux 100 per cent", "Inspect in accordance with Spec. AN-QQ-M-181", "Magnetically inspect with 1000 amperes".

In actuality such requirements mean absolutely nothing, for any inspector can, by varying method, magnetizing current, and other variables of magnetic particle inspection, either pass or reject most parts at will on the basis of such specifications.

There is included (a) no standard test method for the job, and (b) no tolerance—yet much magnetic particle inspection is carried out under such conditions. Many good bolts have been scrapped, much time lost in argument and delayed production, and much hair has been swept from the floors of plants from men who were trying to produce a good product but who were bewildered because there was a mysterious test required but no one agreed on the purpose or application of the test. So they say, "magnetic particle inspection is rejecting too many of our products".

What course can be taken to correct this situation? Who is responsible? Where can we start?

Three groups are involved—the engineers, the metallurgists, and the inspectors—whether they work for the manufacturer, his supplier, or his customer.

The engineer designed the part. He knows its stresses, he knows its service record, he knows the result if failure should occur in service. He has specified its size and shape, its material and strength. Should he not also specify its quality, the types, locations, directions and sizes of "discontinuities", "blemishes", or "defects" which can be allowed?

The metallurgist knows about materials, heat treatment, and allied subjects. He knows materials are not perfect. Should he not also insist on a "tolerance" satisfactory for whatever part is to be made from any material?

The inspector is qualified to inspect and judge the quality of a part, its material, and its manufacture provided he is given the necessary tools, and provided he is given the standards and their tolerances, and access to and cooperation from those who set the standards—the engineer and the metallurgist.

A few months ago W. C. Stewart stated ("Magnetic Inspection", by W. C. Stewart—Fasteners, Vol. 1, No. 2) that something was wrong with magnetic particle inspection because a certain quantity of bolts was sent to several different inspection departments or laboratories one after the other to see how many would fail in this inspection, and widely different percentages were rejected.

This discouraging and seemingly inaccurate result is not damning to the method but is damning to those who sent the bolts and to those who inspected them, for the probabilities are that those who sent them did not also send the standards of acceptance, and those who inspected tried to guess at suitable standards and their guesses were widely divergent.

The manufacturer is entitled to know—yes, he must know—the standards of acceptance of his customer. If too severe, he should attempt to have those standards broadened. The bolt industry has good inspectors, metallurgists, and engineers. Much of the knowledge of bolt design and use lies with

them. There is a challenge to the industry to educate others, to see that inspection is only for true defects which may contribute to service failures; but the selling of such ideas must be backed up by facts and these facts are only obtainable by an investigation of some breadth. It might have as its purposes the determination of the following questions:

1.—Of what effect are seams and inclusions in the shank on the service life of bolts in tension and in shear?

2.—Is there any difference in this effect as the seam or inclusion increases in depth?

3.—Of what effect on the service life are laps in the heads and under the heads at the fillet in headed bolts?

4.—Of what effect on the service life are laps in threads?

Other questions will be apparent to those interested in this problem.

The important thing is that we know what to look for, what is detrimental, what are the standards. It is then a comparatively simple matter to set up a magnetic particle inspection procedure to encompass those standards.

Without them we will all continue blindly to accept or reject bolts on a guess work basis—the guess varying from plant to plant, with each bolt manufacturer, with each parts contractor, with each aircraft manufacturer, and with each Government inspector.

Only the bolt industry has the collective "know how" to do this job. Will it be done?

. . DISCUSSION . . .

. . . the following discussion was prepared jointly by a group of representative engineers of the Aircraft Fasteners Division of the American Institute of Bolt, Nut and Rivet Manufacturers. . . .

The foregoing paper by Mr. Thomas in general demonstrates what the Fasteners Industry has held; namely, that magnetic inspection has a use in any laboratory or even in a plant, but should not in itself be used for final rejection until the causes of magnetic indications are determined for this particular bolt, since the magnetic indications show only a condition without determining the effect of the condition on the service of a bolt.

In a great many ways, magnetic inspection is like using a Shadowgraph which is set to accurately determine what parts are 1 in. in diameter to the hundredth of a thousandth without any additional means of determining the variation from this perfect diameter. To use this for inspecting bolts, specified to be 1 in. in diameter plus or minus .005, would mean that the inspector would use this device and find one or two bolts out of 100,000 that, to his mind, would gage perfectly. The rest might either be too large or too small, but he would have no means of knowing how much they erred from perfection without resorting to other means of measurement.

That is about the position that magnetic inspection occupies in the laboratory. The stand that members of the Aircraft Fasteners Division have taken is that those determinations should be cause for further investigation in relation to the physical condition of the bolt and comparison with known defects, rather than immediate rejection.

Those of us who have had to work with magnetic particle inspection rather question whether or not general limits can be set up by which bolts can be rejected or accepted on magnetic particle inspection alone, for it is not a quantitative measurement. We have seen an instance where a very slight inclusion of about .002 in. presented a similar magnetic indication as did a seam of .014 in. and a quench crack of .200 in., all in the same lot of $\frac{5}{8}$ in. diameter bolts. While it may be possible for a laboratory man to differentiate between the formation and appearance of these indications on these particular bolts, in actual practice we do not be-

lieve it would have been commercially possible to sort out these defects accurately.

The Fasteners Industry has a good background of both technical and working knowledge, and the faults and defects of bolts are quite well recognized. Broadly speaking, there is no need of research to determine what will contribute to service failures. Of those points brought up by Mr. Thomas, the answers have been discussed to such great length that the review of the proceedings of the Aircraft Fasteners Division, even for the short time it has been in existence, would disclose a pretty general working knowledge.

To answer in detail the questions propounded by Mr. Thomas:

1.—There is no reason to believe, and no proof or record of failures to show, that seams or inclusions in the shanks of bolts have any effect whatsoever on the service life of bolts in tension or in shear, since these occur parallel to the axis of the bolt.

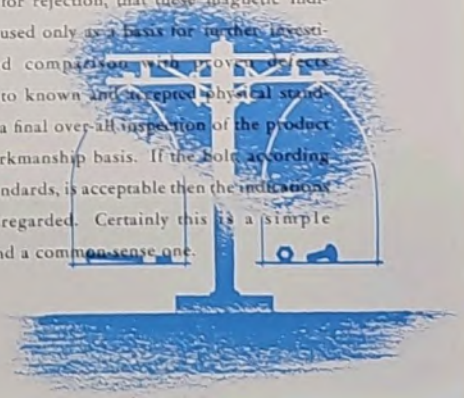
2.—From the above, there would be little difference in the strength of the bolt as the seam or inclusion increased in depth. Long before there would be any question about the working strength being affected by the depth of the seam or inclusion, other defects would occur in the bolt which would cause it to be rejected for poor workmanship. For instance, the head would not be properly formed and there would be severe openings in the side of the facet of the hexagon of the head which any good manufacturer would immediately throw out. Further than this, really deep seams might easily prove to be a source of quench cracks which no manufacturer would attempt to pass as good product.

Frankly, the confusion between quench cracks and seams would appear to be the reason that so much importance has been attached to seams as found by magnetic particle inspection. A quench crack is absolutely cause for rejection, and any lot of bolts with the slightest indication of having quench cracks is recognized as being ruined in heat treating and thrown out by the manufacturer.

3.—No research is necessary to determine the service life of bolts with laps under the head. While such laps are accepted on common bolts they certainly have no place in a high quality, highly stressed product. Conversely, laps in the side of the head caused by re-entrant grain flow at about half way up the side, have no effect on the service life of a bolt since there is no stress involved at this point. If they are severe enough to cause open crevices in the trimming operation, naturally the manufacturer will change his process or throw out any such bolts found with such defects, but more from a workmanship viewpoint than any thought of the service life of the bolts being impaired. Recent tests on $\frac{3}{16}$ in. and $\frac{1}{4}$ in. AN bolts showed that the head heights could be reduced from .125 in. and .156 in. to .075 in. and .090 in. respectively, and yet under tensile tests the bolts broke in the thread section rather than in the head. These were 4037 alloy AN bolts.

4.—Outside of the mechanical difficulties that are experienced from fit of nut on bolt, laps in threads are of small moment in the service life of a bolt.

To sum up, Mr. Thomas questions what is detrimental and what are the standards. Wright Field has stated that the standards are the physical tests plus good workmanship. The Bolt and Nut Industry, with its collective "know how", has insisted that magnetic particle inspection not be used as a final basis for rejection, that these magnetic indications be used only as a basis for further investigation and comparison with proven defects according to known and accepted physical standards, with a final over-all inspection of the product from a workmanship basis. If the bolt, according to these standards, is acceptable then the indications can be disregarded. Certainly this is a simple solution and a common-sense one.



screw threads for *high temperature* bolting

by P. G. SCHULZ, development engineer,
Engineering and Research Division, Crane Company

. . . as oil refineries, steam power plants and similar industrial processes adopt higher temperatures, high-temperature bolting becomes an important problem . . . the use of a definite minimum clearance, allowing space for a lubricant, minimizes galling or seizing. . . .

WITH THE advent of high temperatures in power plants, chemical plants and oil refineries, bolting became a major problem to plant engineers. Carbon steel bolts with their comparatively coarse threads had proven satisfactory on the lower ranges of temperatures but it soon became apparent that materials of greater elastic strength and creep resistance were necessary for the higher temperatures. The American Society for Testing Materials committee on steel specifications authorized a special section of its sub-committee on high-temperature materials to develop specifications for bolting materials. This section subsequently did considerable work in the preparation of A.S.T.M. specifications A96 and A193 covering alloy bolting steels for high temperature service, taking advantage of the developments in steels for this field of application. Material for the accompanying nuts was provided for in a separate A.S.T.M. specification A194, also promulgated by this committee. American Standard B16e-1939, covering 300, 400 and 600 pound steel pipe flanges and flanged fittings, contains stipulations for bolting material in agreement with the aforementioned A.S.T.M. specifications.

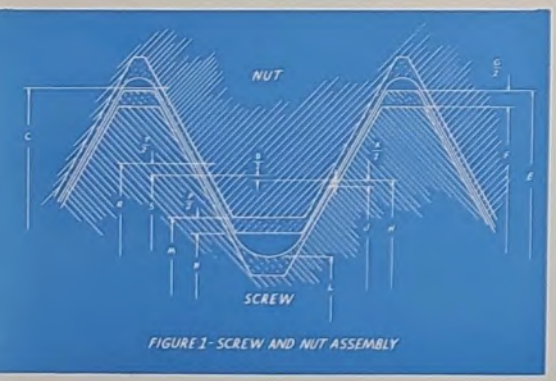


FIGURE 1 - SCREW AND NUT ASSEMBLY

Concurrent with the development of alloy steels for bolting, the question of threading also received considerable attention. One of the first records of bolt troubles due to high temperatures and pressures was at the Commonwealth Edison Company of Chicago. A very thorough study of materials was made, as well as an investigation of threading. The U. S. Standard threads in sizes over 1 in. were relatively coarse and did not lend themselves to high temperature, high pressure service. Tests were conducted on finer pitches as well as other forms, such as buttress, etc., with the subsequent adoption of the 8 thread series of U. S. form for diameters over 1 in. The use of 8 threads per inch provided 5.0 per cent more area at the root of thread on the

1⅛ in. diameter, 8.5 per cent more area on the 1½ in. diameter and 15.2 per cent more area on the 2 in. diameter. At the same time, by virtue of the smaller helix thread angle on the 8 thread series, higher stresses could be set up in the bolting material with no greater torques being applied to the nuts. The Manufacturers Standardization Society of the Valve and Fittings Industry took the first step in establishing a standard practice covering threads for high temperature use with a standard issued in 1932 covering external and internal thread specifications. In this standard the threads per inch on 1 in. diameter and smaller were in accordance with the American Standard A.S.A. B1.1 coarse thread series, and diameters 1⅛ in. and larger were 8 threads per inch. The tolerances established were class 2 for the nuts and class 3 for the bolt studs. The tolerances on the 8 thread series were based on the American Standard 1 in. 8NC, whereas sizes 1 in. and smaller were taken direct from the American Standard. The American Standard was revised in 1935 to include an 8 thread series, and at that time the tolerances were revised somewhat.

It became more and more apparent that an allowance or neutral zone was desirable when using bolting for high temperature work. The allowance, which is an intentional minimum clearance between the pitch diameters of screw and nut is illustrated in Figure 1 by the designation "D". With this space provision for lubricant, the possibility of seizure is minimized when these assemblies are subjected to the high temperatures for which they are recommended. Experience and tests have shown that the use of a suitable lubricant is very essential on bolt threads subject to high temperatures in order to prevent galling or seizing when removing the nuts.

Straight Screw Threads for High-Temperature Bolting

(For Use with Pressure Vessels and Steel Pipe Flanges, Fittings and Valves)

Table 1. Limiting Dimensions and Tolerances for Threads on Screws

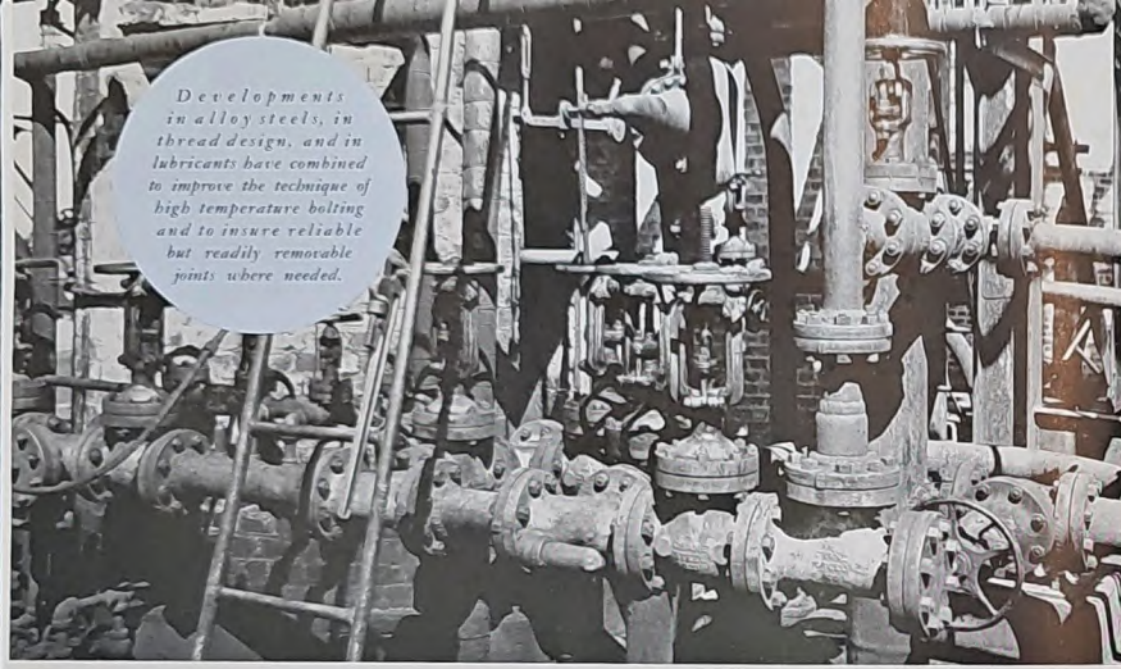
Sizes	Threads per Inch	Basic Major Diameter	Allowance (Minus)[2]	Major Diameter			Pitch Diameter			Minor Diameter Max
				Max	Min	Tolerance	Max	Min	Tolerance[3]	
A	B	C	D	E	F	G	H	I	K	L
¼	20	0.2500	0.0010	0.2490	0.2418	0.0072	0.2165	0.2139	0.0026	0.1877
5/16	18	0.3125	0.0011	0.3114	0.3032	0.0082	0.2753	0.2723	0.0030	0.2422
⅜	16	0.3750	0.0013	0.3737	0.3647	0.0090	0.3331	0.3299	0.0032	0.2970
7/16	14	0.4375	0.0013	0.4362	0.4264	0.0098	0.3898	0.3862	0.0036	0.3486
½	13	0.5000	0.0015	0.4985	0.4881	0.0104	0.4485	0.4448	0.0037	0.4041
9/16	12	0.5625	0.0016	0.5609	0.5497	0.0112	0.5068	0.5028	0.0040	0.4587
⅝	11	0.6250	0.0017	0.6233	0.6115	0.0118	0.5643	0.5601	0.0042	0.5118
¾	10	0.7500	0.0019	0.7481	0.7353	0.0128	0.6831	0.6786	0.0045	0.6254
⅞	9	0.8750	0.0021	0.8729	0.8589	0.0140	0.8007	0.7955	0.0049	0.7366
1	8	1.0000	0.0022	0.9978	0.9826	0.0152	0.9166	0.9112	0.0054	0.8441
1⅛	8	1.1250	0.0024	1.1226	1.1074	0.0152	1.0414	1.0359	0.0055	0.9692
1¼	8	1.2500	0.0025	1.2475	1.2323	0.0152	1.1663	1.1605	0.0058	1.0941
1⅜	8	1.3750	0.0025	1.3725	1.3573	0.0152	1.2913	1.2852	0.0061	1.2191
1½	8	1.5000	0.0027	1.4973	1.4821	0.0152	1.4161	1.4098	0.0063	1.3439
1⅝	8	1.6250	0.0028	1.6222	1.6070	0.0152	1.5410	1.5345	0.0065	1.4688
1¾	8	1.7500	0.0029	1.7471	1.7319	0.0152	1.6659	1.6591	0.0068	1.5937
1⅞	8	1.8750	0.0030	1.8720	1.8568	0.0152	1.7908	1.7838	0.0070	1.7186
2	8	2.0000	0.0031	1.9969	1.9817	0.0152	1.9157	1.9084	0.0073	1.8435
2⅛	8	2.1250	0.0032	2.1218	2.1066	0.0152	2.0406	2.0331	0.0075	1.9684
2¼	8	2.2500	0.0033	2.2467	2.2315	0.0152	2.1655	2.1578	0.0077	2.0933
2⅜	8	2.3750	0.0035	2.3965	2.4813	0.0152	2.4153	2.4071	0.0082	2.3431
2½	8	2.7500	0.0037	2.7463	2.7311	0.0152	2.6651	2.6564	0.0087	2.5929
3	8	3.0000	0.0038	2.9962	2.9810	0.0152	2.9150	2.9058	0.0092	2.8428
3¼	8	3.2500	0.0039	3.2461	3.2309	0.0152	3.1649	3.1556	0.0093	3.0927
3½	8	3.5000	0.0040	3.4960	3.4808	0.0152	3.4148	3.4055	0.0093	3.3426

All dimensions are given in inches.
The American National Form of thread shall be used.
[2]Pitch diameter tolerances include errors of lead and angle.
[3]The maximum pitch diameters of screws are smaller than the minimum pitch diameters of nuts by these amounts.

Table 2. Limiting Dimensions and Tolerances for Threads on Nuts

Sizes	Threads per Inch	Minor Diameter			Pitch Diameter			Major Diameter Min
		Max	Min	Tolerance	Max	Min	Tolerance[2]	
A	B	M	N	P	R	S	T	C
¼	20	0.2060	0.1959	0.0101	0.2211	0.2175	0.0036	0.2500
5/16	18	0.2630	0.2524	0.0106	0.2805	0.2764	0.0041	0.3125
⅜	16	0.3184	0.3073	0.0111	0.3389	0.3344	0.0045	0.3750
7/16	14	0.3721	0.3602	0.0119	0.3960	0.3911	0.0049	0.4375
½	13	0.4290	0.4167	0.0123	0.4552	0.4500	0.0052	0.5000
9/16	12	0.4850	0.4723	0.0127	0.5140	0.5084	0.0056	0.5625
⅝	11	0.5397	0.5266	0.0131	0.5719	0.5660	0.0059	0.6250
¾	10	0.6532	0.6417	0.0126	0.6914	0.6850	0.0064	0.7500
⅞	9	0.7659	0.7547	0.0142	0.8098	0.8025	0.0070	0.8750
1	8	0.8795	0.8647	0.0148	0.9264	0.9188	0.0076	1.0000
1⅛	8	1.0045	0.9897	0.0148	1.0517	1.0438	0.0079	1.1250
1¼	8	1.1295	1.1147	0.0148	1.1771	1.1688	0.0083	1.2500
1⅜	8	1.2545	1.2397	0.0148	1.3024	1.2938	0.0086	1.3750
1½	8	1.3795	1.3647	0.0148	1.4278	1.4188	0.0090	1.5000
1⅝	8	1.5045	1.4897	0.0148	1.5531	1.5438	0.0093	1.6250
1¾	8	1.6295	1.6147	0.0148	1.6785	1.6688	0.0097	1.7500
1⅞	8	1.7543	1.7397	0.0148	1.8038	1.7938	0.0100	1.8750
2	8	1.8795	1.8647	0.0148	1.9292	1.9188	0.0104	2.0000
2⅛	8	2.0045	1.9897	0.0148	2.0545	2.0438	0.0107	2.1250
2¼	8	2.1295	2.1147	0.0148	2.1798	2.1688	0.0110	2.2500
2⅜	8	2.3795	2.3647	0.0148	2.4305	2.4188	0.0117	2.5000
2½	8	2.6295	2.6147	0.0148	2.6812	2.6688	0.0124	2.7500
3	8	2.8795	2.8647	0.0148	2.9318	2.9188	0.0130	3.0000
3¼	8	3.1295	3.1147	0.0148	3.1829	3.1688	0.0132	3.2500
3½	8	3.3795	3.3647	0.0148	3.4321	3.4188	0.0133	3.5000

All dimensions are given in inches.
The American National Form of thread shall be used.
[2]Pitch diameter tolerances include errors of lead and angle.


Developments in alloy steels, in thread design, and in lubricants have combined to improve the technique of high temperature bolting and to insure reliable but readily removable joints where needed.

In various tests, the use of proper lubricant caused a 50 per cent reduction in torque applied to produce a given stress in bolts, in comparison with non-lubricated assemblies and proportional decreases in assemblies with inferior lubricants.

At the outset, manufacturers as well as users established their own standards to provide an allowance. As a result a number of company standards came into existence wherein the dimensions specified varied to some degree. Recognizing the need for a universal standard, the American Standards Association appointed a sub-committee on screw threads for high-temperature bolting in November, 1941. The object of this sub-committee was to develop a proposed American standard which would definitely specify the limiting thread dimensions for high temperature bolting. Some work was done in correlating the various existing company standards and some progress had been made on this subject when the War Production Board requested the American Standards Association to apply the war standards procedure to this project in order to expedite the work. Therefore, in June, 1942, a war emergency committee was appointed, which prepared a standard approved and issued November, 1942, as American War Standard A.S.A. B1.4-1942. This standard establishes the coarse thread series for sizes 1 in. and smaller and the 8 thread series for $1\frac{1}{8}$ in. and larger. Both series are given in the American Standard B1.1-1935. The limiting thread dimensions which are shown in Tables 1 and 2 were established as stated in the following quotation from the standard:—

> "To facilitate assembly of the threaded parts and reduce the possibility of seizure of the threads, this standard provides an allowance or neutral zone between the minimum nut and the maximum screw. This allowance is obtained by making the maximum pitch diameter of the screw smaller than the minimum pitch diameter of the nut by an amount equal to the difference between the class 2 and 3 tolerances specified in the American Standard B1.1–1935, for the nominal diameter concerned. The

Fasteners Digest

The riveting of aluminum parts differs from the riveting of other metal structures only in material and certain phases of procedure. There are five aluminum alloys used commercially in the form of rivets: 2S, A-17-S, 17-S-T, 24-S-T, and 53-S-T-61. The average ultimate shear strength and bearing strength for cold driven rivets of these alloys are, respectively: 11,000, 33,000, 39,000, 42,000, and 23,000 psi.

Aluminum rivets are produced in sizes ranging from 1/8 in. to 3/4 in. Some 7/8 in. and 1 in. sizes have also been produced. A wide range of lengths are available, as well as a wide variety of heads.

Aluminum rivets in the smaller sizes may be driven cold by hammer or squeezing with satisfactory results. Over 1/2 in. in diameter, heat is desirable if the rivets are to be hammer driven. The tools for driving aluminum rivets are much the same as those used in riveting other metals.

Steel rivets, both hot and cold driven, have been used successfully in aluminum alloy structures. They are stronger than aluminum alloy rivets, but care must be exercised to avoid local overheating of the aluminum alloy parts resulting from the use of hot rivets.

"Joining Aluminum Alloys", by E. C. Hartmann, G. O. Hoglund and H. A. Miller, Aluminum Company of America—Steel, August 7, 1944.

For use by allied armies, bolted sectional steel barges are being produced at a number of plants by prefabrication in standard panels and sections which are shipped abroad in knocked-down condition and assembled at the point of use, employing nuts and bolts. The barges have a capacity of more than 500 tons and are 104 ft. long, 29 ft. wide and 9 ft. from deck to bottom. Fabricated to tolerances of 1/8 in. in 104 ft., all sections and panels are interchangeable. With trained supervisors, unskilled personnel has assembled one of these barges in 500 man-hours.
Construction Methods—April, 1944.

Wartime demands not only have increased the variety of special nuts required by aircraft manufacturers but have established stricter standards of precision. Most of the nuts used are tapped to a class 3 fit and the thread is required to run 90 degrees to the face, plus or minus 0.001-inch. In addition, many nuts must be hardened to as high as 36 Rockwell C before tapping which has further complicated production from the standpoint of the maker of nuts. This has been met, however, by the addition of more precision equipment making it possible to accurately control the tapping procedure.
Steel, May 8, 1944.

Power brushing, using rotating wire or tampico brushes, is widely used to remove small burrs remaining on metal parts after their manufacture. In one case, burrs are removed from the slots and upper portions of the threads of castellated nuts by an 8 in. diameter wheel fitted with .0095 in. crimped steel wire and operated at approximately 3000 r.p.m. Heat treating scale and other undesirable material adhering to parts may be removed from threads rapidly by such methods.

"Deburring Aluminum and Light Steel Parts", by G. O. Rowland, Osborn Manufacturing Company, Cleveland, Ohio.—Iron Age, January 27, 1944.

The "feel" of a properly tightened nut and bolt can be acquired by practice, wrenching up the nut until the bolt seems to be pushing the wrench back where it came from. As a check on the proper tightening, the bolt length can be measured with a micrometer before and after tightening. For each inch of bolt length, the ideal amount of stretch in a properly tightened bolt is .003 in. Actually, a stretch ranging .002-.004 in. is satisfactory. Practice, checked by measurement of stretch will develop the "feel" for tightness.
"How Tight is Tight?"—United States Army Ordnance Department.

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screw has been given a class 3 tolerance so that the minimum pitch diameter of the screw is equal to the minimum pitch diameter of a class 2 screw according to B1.1-1935.

"In conformance with American Standard practice, the basic nut has been retained, the allowance being taken exclusively from the screw. Class 2 tolerances have been adopted for the nuts. All nut dimensions given in this standard are in agreement with those given in the American Standard B1.1-1935, for class 2 product.

"Pitch diameter tolerances are cumulative and include lead and angle variations. They are based on a length of engagement of 1 x major diameter for sizes 1 to 3 inches, inclusive, and a length of engagement of 3 inches, for sizes over 3 inches."

The Manufacturers Standardization Society revised its standard practice in March, 1943, to be in agreement with the War Standard B1.4. A poll of members indicates that the standard enjoys widespread use. Recently, members of the A.S.A. subcommittee were requested to state their opinions as to the advisability of submitting the War Standard B1.4 as a regular American standard. Replies received definitely prove the merits of the principles set forth in the standard and there is little doubt that B1.4 will soon become a regular American standard.

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